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Development and Characterization of Hard Candy Enriched with Betel Leaf (*Piper betle*) and Lime (*Citrus aurantifolia*)

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ABSTRACT

Hard candy has a hard texture and looks transparent and shiny (glossy) with the main ingredients of sucrose, glucose syrup, and water. At present, the majority of hard candies available on the market do not contain functional components. Therefore, the development of this hard candy aims not only to provide sensory satisfaction but also to offer potential health benefits. The aim of this study is to evaluate the effect of adding betel leaf and lime on the sensory quality of hard candy, determine the most preferred formulation, and conduct chemical analysis to assess its nutritional content. The treatment in this study was the ratio of betel leaf extract and lime extract to replace water in the formulation, namely 80%: 20%, 60%: 40%, 40%: 60%, and 20%: 80%. Based on sensory tests, using betel and lime to process hard candy significantly affects appearance, color, texture, and taste. Hard candy with a ratio of betel leaf extract and lime extract of 80%:20% is the best assessment, with panelist assessments of appearance 4.20 (like slightly), color 3.97 (like slightly), aroma 3.43 (neutral), taste 3.97 (like slightly), and texture 4.07 (like slightly). Hard candy with a ratio of betel leaf extract and lime extract of 80%:20% has a water content of 2.34%, ash content of 0.29%, reducing sugar 28.39%, saccharose 49.56%, vitamin C 38.22 mg/100g, and total phenol 126.9065 mg GAE/100ml. Bases on the result of this study, the ginger and lime hard candy may serve as a functional product option with potential health benefits.

Keywords: *Hard candy, betel leaf, lime*

INTRODUCTION

Candy is one of the sweet food products that various groups of people highly favor. Candy is a confectionery generally made from sugar at a specific concentration, mixed with water, and added flavorings and colorings (Rahmawati et al., 2023). Based on its texture, candy is divided into two categories: hard candy and soft candy, with a solid and firm texture, while soft candy has a softer consistency (Jumri et al., 2015). Based on crystal formation, candies can be categorized into crystalline and non-crystalline (amorphous) candies. Crystalline candies are characterized by their distinct creamy texture and flavor when consumed, with examples including fondants, fudge, penuche, and divinity. In contrast, non-crystalline candies—often called "candies without form"—do not form crystals during cooking, resulting in a coarse texture and making them more challenging to shape. Examples of non-crystalline candies include caramels, hard candies, lollipops, marshmallows, and gumdrops (Koswara, 2009).

Hard candy is the most commonly found type and is often preferred by consumers due to its clear and attractive appearance. Hard candy is defined as candy with a hard texture and a clear, glossy look, primarily made from granulated sugar (sucrose), glucose syrup, and water (Ramadhan, 2012). As public awareness of the relationship between food and health grows, food trends increasingly shift toward functional foods. These are foods that not only satisfy the palate but also provide health benefits. Bases on the result of this study, the ginger and lime hard candy may serve as a functional product option with potential health benefits.

Betel (*Piper betle*) is a type of plant whose leaves are traditionally used for medicinal purposes and are part of cultural practices in several Asian countries, including Indonesia, where

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betel chewing is common. Betel has numerous benefits and bioactive compounds, including antimicrobial, antioxidant, anticancer, anti-cholesterol, anti-inflammatory, analgesic, immunomodulatory, and hepatoprotective (Silalahi, 2019). According to Rahayu et al. (2016), the ethyl acetate extract of green betel leaves contains 31 compounds, with the main components being eugenol (25.03%), 2,5-dimethyl benzoic acid (12.08%), decahydro-4a-methyl-1-methylene naphthalene (7.18%), 1,2,3,4,4a,5,6,8a-octahydro-7-methyl naphthalene (8.36%), and 1,2,3,4,4a,5,6,8a-octahydro-4a-methyl naphthalene (13.43%).

The use of betel leaf extract in hard candy is expected to enhance the quality of the candy, not only adding flavor and aroma but also offering health benefits. However, its bitter taste often hinders the application of betel in food products. Therefore, it is combined with lime juice to reduce or even cover up the bitter taste.

Lime (*Citrus aurantifolia*) is a citrus plant originally found in Southeast Asia and India. Lime fruit is commonly used as a remedy for coughs and colds, to reduce phlegm, as an antipyretic, acne treatment, remedy for diarrhea, anti-inflammatory, anti-rheumatic, anticoagulant, anti-infection, and antibacterial. Studies show that lime juice contains flavonoids, alkaloids, phenols, and tannins (Bawekes et al., 2023). Lime is known to contain various bioactive compounds such as flavonoids, saponins, and essential oils composed of siral, limonene, phellandrene, and the glycoside hesperidin. Additionally, its juice contains limonene and approximately 7% citric acid Pratiwi dan Ferdiansyah, (2017.) In food processing, lime extract is often used as a flavor enhancer, deodorizer, and source of sour taste. Lime is a good source of vitamin C, which acts as an antioxidant.

To produce hard candy with betel and lime that has the best sensory characteristics and is acceptable to consumers, sensory analysis is needed to assess consumer preference across various combinations of betel and lime, and this will help determine the best formulation. According to Pratiwi (2023), hard candy production using ginger extract and lime extract with formulation of 80%:20%, 60%:40%, 40%:60%, and 20%:80% showed the best results at the 60%:40% combination.

The study of adding betel and lime to hard candy processing is to determine the sensory characteristics of the candy produced in various treatments, determine the most preferred treatment, and continue with chemical analysis for further evaluation. Through this research, ginger and lime hard candy are expected to become a functional product option that provides health benefits.

METHODS

Material

The ingredients used to process betel and lime hard candy include betel leaves, lime,sucrose, glucose syrup, and water. The testing materials used include 20% KI 20%(potassium iodide), 4 N sulfuric acid, 0.1 N sodium thiosulfate, 1% starch, distilled water, 30% HCl (hydrochloric acid), 25% NaOH (sodium hydroxide), Luff solution, sulfuric acid, 0.1 N iodine, Folin-Ciocalteu reagent, and 17.5% Na_2CO_3 (sodium carbonate).

Equipment

The equipment used to process betel and lime hard candy includes a stove, steamer, pan, strainer, weighing scale, measuring jug, molds, knife, and stirring spatula. The testing equipment used includes a furnace, desiccator, crucible, porcelain dish, oven, tongs, wire mesh for blender, volumetric flask, reflux condenser, titration apparatus, dropper pipette,

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erlenmeyer flask, water bath, measuring flask, test tubes, a set of spectrophotometer tools, and volumetric pipette.

Procedure

Preparation of Betel Leaf Extract and Lime Extract

The betel leaf extract is prepared by boiling betel leaves and water at 1:1. The boiling process continues until the mixture reduces to approximately half the original water volume, for about 15 minutes. The resulting betel leaf extract is then cooled and filtered. For the lime extract, the limes are cut and squeezed to obtain the juice, followed by filtration to separate the extract.

Processing of Betel Leaf and Lime Hard Candy

The production process of betel leaf and lime hard candy includes several stages: preparation of ingredients, which involves making betel leaf extract and lime extract, followed by mixing the betel leaf extract with granulated sugar. Once mixed, glucose syrup and lime extract are added, and the mixture is cooked for 20 minutes, then molded and cooled. Figure 1 shows the flowchart of the processing of betel leaf and lime hard candy.

Research Design

This study was conducted using a Completely Randomized Design (CRD) with a single factor, namely the combination ratio of betel leaf extract and lime extract used as a substitute for water in the production of hard candy. There were four treatment variations, as follows:

Treatment A = Ratio of betel leaf extract to lime extract 80%:20%
Treatment B = Ratio of betel leaf extract to lime extract 60%:40%
Treatment C = Ratio of betel leaf extract to lime extract 40%:60%
Treatment D = Ratio of betel leaf extract to lime extract 20%:80%

The formulation of betel leaf and lime hard candy can be seen in Table 1.

Table 1. Formulation of Betel Leaf and Lime Hard Candy

Ingredient	Unit	Amount			
		A	B	C	D
Granulated sugar	g	140	140	140	140
Glucose syrup	g	40	40	40	40
Betel leaf extract	g	40	30	20	10
Extract lime	g	10	20	30	40

Test Parameters

The analysis conducted in this study was sensory analysis, which was carried out with 30 semi-trained panelists. and assessed parameters including appearance, color, aroma, taste, and texture. The hard candy with the highest acceptance was then subjected to chemical analysis, which included tests for moisture content, ash content, reducing sugar, sucrose, vitamin C, and total phenolic content.

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Data Analysis

The data analysis for sensory characteristics was conducted using Analysis of Variance (ANOVA). If a significant difference was found, it was followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level.

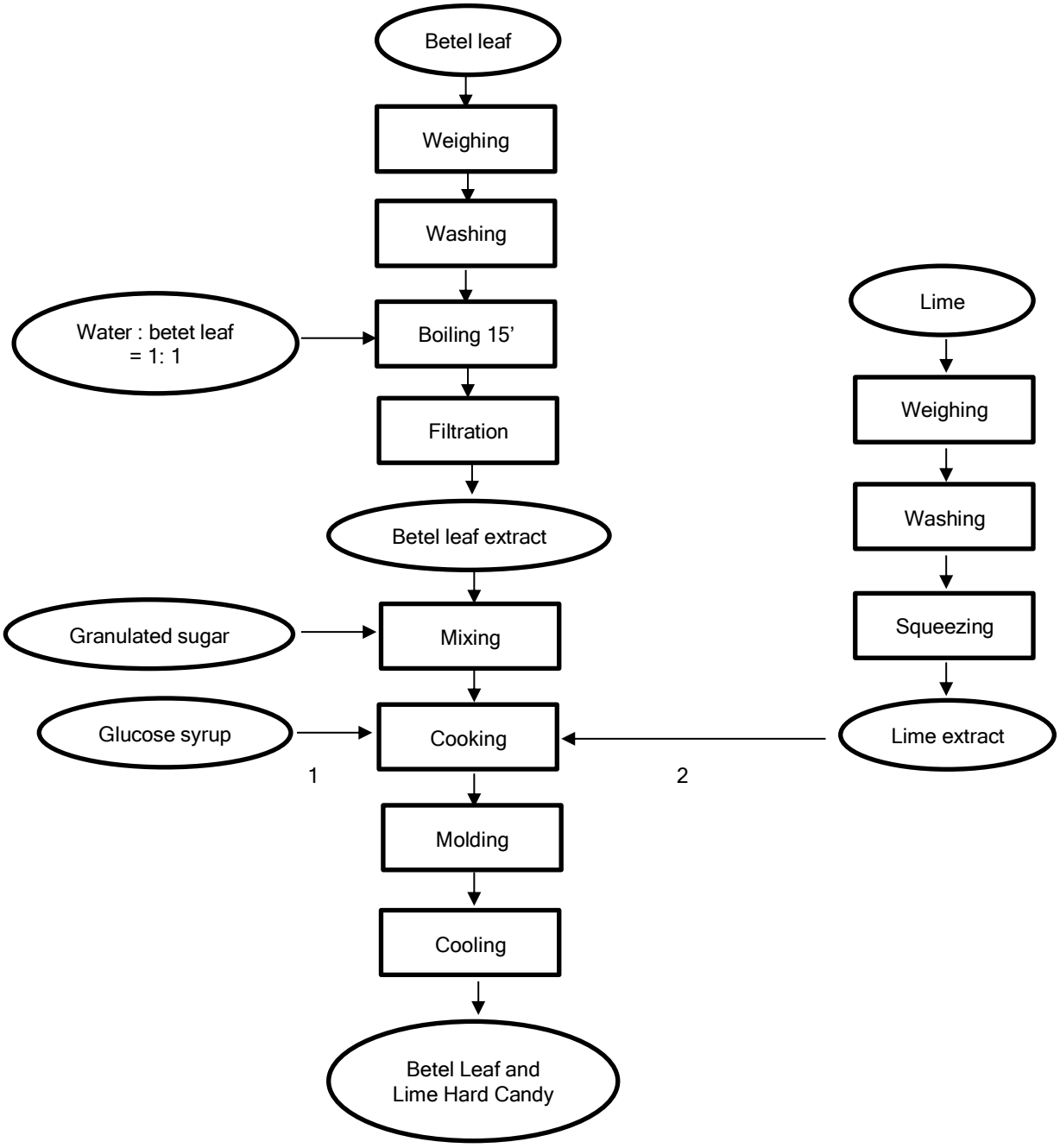

Figure 1. Flowchart of the Processing of Betel Leaf and Lime Hard Candy

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RESULT AND DISCUSSIONS

Sensory Analysis

Based on the sensory test conducted, the results showed that the ratio of betel leaf and lime extract significantly affected the appearance, color, taste, and texture of the hard candy, but had no significant effect on the aroma. Table 2 shows the sensory test results for betel leaf and lime hard candy.

Table 2. Sensory Analysis of Betel Leaf and Lime Hard Candy

Teatment (betel leaf extract : lime extract)	Parameter				
	Appearance	Color	Aroma	Taste	Texture
A (80% : 20%)	4.20[a]	3.97[a]	3.43[a]	3.97[a]	4.07[a]
B (60% : 40%)	3.73[b]	3.60[a]	3.43[a]	3,87[a]	3.37[b]
C (40% : 60%)	3.03[c]	3.13[b]	3.23[a]	2.77[b]	2.57[c]
D (20% : 80%)	2.70[c]	2.80[b]	3.70[a]	2.73[b]	2.53[c]

Note: Numbers followed by the same small letter in the same row and column are not significantly different according to the Duncan Multiple Range Test (DMRT) at the 5% significance level.
Description of scores: 5 (like), 4 (like slightly), 3 (neutral), 2 (dislike slightly), 1 (dislike).

The panelists gave the highest score for the appearance parameter to the hard candy with a ratio of betel leaf extract and lime extract of 80%:20%, with a score of 4.20 (like slightly). The difference in appearance among the complex candy samples was due to the varying amounts of lime extract. The higher the amount of lime extract, the lower the clarity of the hard candy. In treatments C and D, with 60% and 80% lime extract, the resulting hard candies appeared cloudy and lacked transparency. According to Haloho & Handoko (2023), acid can hydrolyze sucrose into reducing sugars, increasing total dissolved solids. This increase in dissolved solids causes turbidity in the hard candy, reducing its clarity as lime extract increases.

The panelists also gave the highest score for the color parameter to the hard candy with a ratio of 80% betel leaf extract to 20% lime extract, scoring 3.97 (like slightly). The pigment content influenced the differences in color in betel leaves. Green betel leaves contain various pigments such as pheophytin a, chlorophyll a, chlorophyll b, xanthophyll, carotene, and anthocyanin (Muthoharoh, 2011 *cit*. Ruslan & Purwati, 2021). The combination of pheophytin, xanthophyll, carotene, and anthocyanin from the betel leaves resulted in a yellow-colored hard candy. As the amount of betel leaf extract decreased, the yellow color became darker. This effect was exacerbated by the increased use of lime extract, which contains high levels of vitamin C and accelerates non-enzymatic browning reactions due to high-temperature processing. According to (Aryani & Mu'awanah, 2019), vitamin C is a reducing compound that also acts as a precursor in non-enzymatic browning reactions. This browning is the initial stage of the Maillard reaction. This reaction can occur because vitamin C is a reducing agent and functions as a non-enzymatic browning color former.

All treatments produced hard candy with a combined betel leaf and caramel aroma. The differences in the concentration of betel leaf extract and lime extract had no significant effect on the aroma. This is due to the high temperature during processing, which causes the evaporation of flavor components from both the betel leaf and the lime. Specifically, eugenol from the betel leaf and terpene compounds such as α-pinene, β-pinene, limonene, and phellandrene from the lime are volatile and evaporate under heat. According to Izah et al. (2023) the flavor components

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evaporated when exposed to high temperatures in their study on producing hard candy from kenikir leaves and lime.

The panelists gave the highest score for the taste parameter to the hard candy with a ratio of 80% betel leaf extract and 20% lime extract, scoring 3.97 (like slightly). The variation in taste among the hard candy samples was attributed to the different amounts of lime extract used. The more lime extract added, the more bitter the candy became. This bitterness is due to naringin, a bitter compound from the lime peel that can be carried over during extraction. Ideally, the lime peel should be removed prior to extraction. According to Fakhira et al. (2023), lime peel contains bitter-tasting essential oils and various chemical compounds such as flavonoids, terpenoids, phenolics, limonoids, and alkaloids. Choi (2007) also reported that lime peel contains flavonoid compounds including naringin, hesperidin, naringenin, hesperetin, rutin, nobiletin, and tangeretin. According to Sagala et al. (2017), naringin is the compound that causes the bitter taste in lime peels.

The panelists gave the highest score for the texture parameter to the hard candy with a betel leaf extract and lime extract ratio of 80%:20%, scoring 4.07 (like slightly). The texture of hard candy is influenced by the pH level, which in this case is affected by the use of lime extract. According to Mandei & Nuryadi (2019), candies produced using ingredients with a pH of 5 to 6 tend to have a hard and non-sticky texture. Meanwhile, candies made from more acidic ingredients result in higher levels of reducing sugars due to the inversion of most sucrose (table sugar) into glucose and fructose. The level of reducing sugars is directly proportional to the stickiness of the candy; the higher the reducing sugar content, the stickier the candy becomes.

Sensory testing indicated that the best ratio of betel leaf extract to lime extract in the production of hard candy was Treatment A (80%:20%). This selected treatment was then subjected to further chemical analysis, including tests for moisture content, ash content, reducing sugar, sucrose, vitamin C, and total phenols.

Chemical Analysis of Betel Leaf and Lime Hard Candy

Chemical tests conducted on the hard candy with betel leaf extract and lime extract included analyses for moisture content, ash content, reducing sugars, sucrose, vitamin C, and total phenols. The results are presented in Table 3 below.

Table 3. Chemical Analysis of Betel Leaf and Lime Hard Candy

Parameter	Unit	Value
Moisture content	%	2.34
Ash content	%	0.29
Reducing sugars	%	28.39
Sucrose	%	49.56
Vitamin C	mg/100g	38.22
Total phenols	mg GAE/100ml	126.9065

Moisture Content

The moisture content of the betel leaf and lime hard candy product was found to be 2.34%. According to the Indonesian National Standard (SNI) 3547.1:2008, hard candy's maximum allowable moisture content is 3.5% (Badan Standardisasi Nasional, 2008).Therefore, the betel leaf and lime hard candy meet the established standard. The cooking process can affect the moisture content in hard candy, as using temperatures above the boiling point reduces the moisture level in the product. High temperatures cause the water in the candy-making process to evaporate, thereby lowering the moisture content to 2.34%. According to Kuzu et al. (2024),

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the production of hard candy involves moisture reduction through thermal processing. As the cooking temperature increases, the evaporation rate also rises, decreasing residual moisture in the final product. Several studies have shown that candies cooked at temperatures between 135°C and 145°C experience significant moisture loss, supporting conventional approaches to moisture control in candy manufacturing.

Ash Content

The ash content of the hard candy with the addition of betel leaf and lime extract was 0.29%. This total ash content meets the standard, as SNI 3547.1:2008 specifies a maximum ash content of 2.0% for hard candy. Food's ash content is related to a material's mineral content. Low ash content is an important parameter in assessing hard candy's quality, as it enhances the product's visual appearance. Hard candy tends to appear better when its ash content is lower. Hard candies with lower ash content tend to exhibit a clearer and more transparent appearance, resembling the clarity of water (Izah et al., 2023). Furthermore, the ash content in hard candy is influenced by the ingredients used in the production process. Sucrose and glucose used in the formulation contribute to the ash content. The minerals found in sugar include calcium and phosphorus (Suhardiyanto et al., 2023).

Reducing sugars

The reducing sugar content of the hard candy with added betel leaf and lime extract was found to be 28.39%. According to the Indonesian National Standard (SNI) 3547.1:2008, hard candy's maximum allowable reducing sugar content is 24%, meaning the product does not meet the established quality standard. The amount of reducing sugar can be influenced by the level of sucrose used. The higher the amount of granulated sugar (sucrose) used or the lower the amount of invert sugar or glucose added, the higher the reducing sugar content in the betel leaf and lime extract hard candy. The inversion or acid hydrolysis of sucrose into glucose and fructose leads to an increase in reducing sugar (Yazakka & Susanto, 2015) . According to Mandei & Nuryadi (2019), the inversion of reducing sugar can be influenced by temperature, heating duration, and acid concentration.

Sucrose content

Sucrose content is a parameter that affects the quality of hard candy, as sucrose is used to provide a sweet taste. Based on the test results, the sucrose content was found to be 49.56%. This value meets the quality standard, as SNI 3547.1:2008 specifies a minimum sucrose content of 35% for hard candy. The sucrose content in hard candy is significantly influenced by the amount of sucrose used in the formulation (Rifqi et al., 2022) The pH value of hard candy affects the stability of sucrose content because acidic pH causes the inversion of sucrose into glucose and fructose (Erwinda & Susanto, 2014). A higher pH will inhibit the sucrose inversion reaction, increasing sucrose content in the hard candy. Using acidic lime extract tends to lower the sucrose content in hard candy.

Vitamin C

Total vitamin C content in the hard candy was 38.22 mg/100g. According to Ariani & Lalu (2023), the vitamin C content in fresh lime juice is approximately 0.05% or 0.05 g, which equals 50 mg. The temperature and duration of the hard candy cooking process influence the vitamin

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C content. Cooking at high temperatures tends to reduce vitamin C levels. The higher the temperature and the longer the cooking time, the greater the degradation of vitamin C. Short-duration cooking at high temperatures causes only slight vitamin C loss. In contrast, long cooking times at lower temperatures significantly degrade vitamin C (Icha, 2021). The vitamin C source in this study was extracted from lime juice through squeezing.

Antioxidants are compounds that neutralize or inhibit the damaging effects of free radicals in the body. Due to their high reactivity, antioxidants are easily oxidized and thus react first with free radicals, protecting vital cellular molecules from oxidative damage (Rosida et al., 2023). Although the body naturally produces antioxidant enzymes to counteract free radicals, an excessive accumulation of free radicals can overwhelm the body's defense system, leading to oxidative stress. On the other hand, food processing methods, particularly those involving heat, such as candy production, can significantly reduce vitamin C content. Several studies have indicated that even short-term exposure to high temperatures can lead to substantial vitamin C degradation, ultimately decreasing the nutritional quality of the final product. For instance, prolonged heat treatments such as boiling or sterilization have been shown to markedly reduce vitamin content, including vitamin C (Seema & Yadava, 2017).

This is also in line with the findings of Choiron et al. (2018) and Budi & Amelia, (2022) , who stated that an increase in processing temperature tends to elevate the risk of vitamin C degradation in food materials. Exposure to high temperatures can cause vitamin C to oxidize into dehydroascorbic acid, which may further break down into diketogulonic acid. This compound no longer possesses biological activity as vitamin C.

Total phenol

Total phenol content measured using the spectrophotometric method was 126.9065 mg GAE/100ml. The total phenol content in the hard candy with added betel leaf and lime extract was influenced by both the extraction and processing methods. The extraction of betel leaf using boiling reduced its phenolic content due to high heat, and the candy-making process, which involves prolonged heating at temperatures around 130–140°C, further contributed to the reduction. According to Permata et al. (2018),the total phenol content in lime extract is around 116.5 mg GAE/100ml. The ripeness level of the lime affects its phenolic content—the riper the fruit, the lower the phenol level, and vice versa. According to Primadiamanti & Amura (2020), the total phenol content in betel leaf is approximately 164.56 mg/100ml when extracted using the maceration method, which helps minimize the loss of phenols due to their volatile nature.

In this study, the extraction process can be carried out using alternative methods to obtain a higher concentration of extract, which may enhance the total phenolic content and ultimately result in a functional product with potential health benefits. Furthermore, the availability of betel leaves may become a limiting factor in this research. Therefore, it is hoped that this study will encourage the community to cultivate betel plants and utilize them more effectively in food processing.

CONCLUSION

This study showed that the ratio of betel leaf extract to lime extract significantly affected the hard candy's appearance, color, taste, and texture. At the same time, it had no significant effect on aroma. The best results were obtained from the 80%:20% ratio, with panelist scores of 4.20 (like slightly) for appearance, 3.97 (like slightly) for color, 3.43 (neutral) for aroma, 3.97 (like

slightly) for taste, and 4.07 (like slightly) for texture. The chemical analysis of the betel and lime hard candy showed a moisture content of 2.34%, ash content of 0.29%, reducing sugar content of 28.39%, sucrose content of 49.56%, vitamin C content of 38.22 mg/100g, and total phenol content of 126.9065 mg GAE/100ml. To meet the quality standards for reducing sugar as stated in SNI 3547.1:2008, the concentrations of sucrose and glucose used in the formulation can be reduced. This study indicates that betel leaf and lime hard candy could serve as a functional food product offering beneficial health effects.

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